PLASMA PHYSICS ABSTRACTS

1 JANUARY 1970 THROUGH 31 DECEMBER 1970

by

DAVID C. MONTGOMERY

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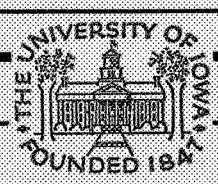

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This collection of abstracts represents those plasma physics publications from the Department of Physics at the University of Iowa which are considered relevant to NASA Grant NGL-16-001-043.

The last such collection was issued on December 31, 1969. The numbering scheme continues consecutively with that used in this earlier report.

A. THEORETICAL

32. Quasilinear Theory of the Ion-Wave Instability
David Montgomery and George Vahala
Proc. of Third European Fusion Conference and Symposium on Beam-Plasma Interactions, Utrecht, Netherlands, June 23-27, 1969; p. 104.

The ion-wave instability is treated within the framework of two-species quasilinear theory. The electrons are assumed to drift, relative to the ions, along a strong d.c. magnetic field. Such situations can arise both in laboratory discharges and in the solar wind. It is found that, as in the case of unstable electron plasma oscillations in the one-species plasma, there exists a unique final state for a given set of initial conditions; the spectral density of the fluctuating electric field can be determined. The results differ in some respects from the more usual quasi-linear results. Some speculations on the three dimensional case (no strong d.c. magnetic field) are offered.

33. Thermal Relaxation in One and Two Dimensional Plasma Models
D. Montgomery and C. W. Nielson
Phys. Fluids, 13, 1405 (1970).

Thermal relaxation of stable one and two dimensional plasmas is followed in time by particle-in-cell numerical computation. The predicted dependences of relaxation rate on plasma parameter are observed.

34. Validity of the Electrostatic Approximation
David Montgomery
Phys. Fluids 13, 1401 (1970)

Criteria are derived for the existence of normal modes in a magnetized plasma for which $| \nabla \times \vec{E} | << | \nabla \cdot \vec{E} |$. The condition is different from the frequently quoted condition of thermal pressure << magnetic pressure.

35. Discrete Spectra and Damped Waves in Quasilinear Theory
G. Vahala and D. Montgomery
J. Plasma Phys. 4, 677 (1970)

The consequences of the quasilinear equations are explored. Particular attention is paid to the differences between the one-dimensional and the two- and three-dimensional cases, and to the differences between the cases of discrete and continuous wave-number spectra. The possibilities of and problems associated with including damped waves are treated. The relation between conservation laws and the 'resonance approximation', in which the limit of zero growth rate for the unstable waves is taken at finite times, is clarified. Numerical solutions for the one-dimensional case with finite growth rate are presented.

36. Theory of the Unmagnetized Plasma
D. Montgomery
[Book; about 400 pp.; to be published by Gordon & Breach, 1971]

[No Abstract]

37. Comment on Negative Diffusion Coefficients in Quasilinear Theory
D. Montgomery and S. Bodner
[To be published in J. Plasma Phys., 1971]

A recent paper on quasilinear theory by Klozenberg and Bernstein is commented upon. It is argued that improper treatment of the perturbed electron distribution for damped waves has led to a diffusion-type equation with a negative diffusion coefficient.

38. Parametric Amplification of Alfvén Waves
G. Vahala and D. Montgomery
[Submitted to Physics of Fluids]

A calculation describing the parametric amplification of Alfvén waves in a uniform, perfectly-conducting, magnetohydrodynamic fluid is reported. The calculation has been motivated by a recent experiment of Lehane and Paoloni. A magnetically-supported uniform column of the magnetohydrodynamic fluid is imagined to be subjected to an externally-imposed, sinusoidally-varying, magnetic field which can be idealized as spatially-uniform. It is shown that a certain class of Alfvén waves which have an axial wavelength long compared to the radius of the column can be parametrically amplified in the case where their frequency and the modulating frequency satisfy certain integer quotient relations. The mathematical behavior is determined by Mathieu equations.

39. Electric Conductivity of Weakly Turbulent Plasmas
Y. H. Ichikawa (visitor from Nihon University, Tokyo) and K. Nishikawa
[Accepted for publication by Physics of Fluids]

The static electric conductivity of weakly turbulent plasmas has been examined on the basis of a kinetic equation for the linear response to the one particle distribution function. Within the regime of neglecting the mode-coupling terms, the high frequency turbulent fluctuations associated with the electron plasma wave gives rise to a modification of the ordinary collisional conductivity through the adiabatic interaction between the particles and the turbulent fluctuations. On the other hand, the low frequency turbulent fluctuation due to the ion oscillation mode determines the relaxation process in the system through the resonant interaction, and gives rise to a finite conductivity even in the collisionless plasmas.

40. Effects of Bunched Ion Bursts on Apparent Nonlinear Ion Acoustic Waves
Y. H. Ichikawa (visitor from Nihon University, Tokyo)
[Accepted for publication by Physics of Fluids]

The bunching effects of ions at the excitation grid in a typical ion acoustic wave experiment are examined by applying the generalized quasi-linear theory of Al'tshul and Karpman to a simple model of the grid-plasma system.

The resulting bunched ion bursts exhibit amplitude modulation at a distance far from the grid. The characteristics of this amplitude modulation are in complete agreement with the recently observed results of Sato et al. who interpreted their results in terms of nonlinear Landau damping of ion acoustic waves.

B. IONOSPHERIC ABSTRACTS

19. Satellite Measurements of DC Electric Fields in the Ionosphere
D. A. Gurnett
Particles and Fields in the Magnetosphere, 309, Reinhold Book Co., N. Y. (B. M. McCormac, ed.), 1970.

This paper presents initial results from the DC electric field experiment on the low altitude polar orbiting INJUN 5 satellite. At low latitudes, where the ionospheric plasma is expected to corotate with the Earth, the only observed electric field is the $\vec{V} \times \vec{B}$ electric field due to the motion of the satellite through the ionosphere. Comparisons of the computed $\vec{V} \times \vec{B}$ field agree with the measured electric field within about ±10 mV/meter. At the plasmapause boundary small changes (~5 to 15 mV/meter) in the dc electric field are observed which are believed to be due to magnetospheric convection phenomena at the plasmapause boundary. At high latitudes large amplitude (~100 mV/meter) electric field irregularities and disturbances, believed to be due to ionospheric electric fields, are observed on virtually every passage over the polar regions. Long period electric field oscillations with periods on the order of 15 seconds are also commonly observed at high latitudes.

20. Observations of 8-AMU/Unit Charge Ion Cyclotron Whistlers
D. A. Gurnett and P. Rodriguez
J. Geophys. Res. 75, 1342, 1970.

A new type of ion cyclotron whistler associated with ions having a mass-to-charge ratio of 8-amu/unit charge is reported from very-low-frequency (VLF) radio noise observations with the Injun 5 satellite. This observation confirms earlier measurements by the Explorer 31 satellite identifying the presence of 8-amu/unit charge ions in the ionosphere and represents the third type of ion cyclotron whistlers found in satellite VLF data. From crossover frequency measurements the fractional concentration of the 8-amu/unit charge ions has been determined to be a few percent or less. This new ion cyclotron whistler has been observed most often during local night, at altitudes ranging from 1200 km to 2100 km and invariant latitudes from 37° to 58°.

21. Conjugate Photoelectron Impact Ionization
S. D. Shawhan, L. P. Block, and C.-G. Fälthammar
(accepted for publication, J. Atmos. Terr. Phys., 1970).

The exchange of photoelectrons between ionospheres in a matter of minutes rather than at the slow ambipolar speed is discussed. It is shown that the electron density may be affected by secondary processes resulting from the conjugate photoelectron flux but not by the flux itself.

The flux spectrum of conjugate photoelectrons throughout the day at the solstices for minimum solar activity is calculated for 55° N. geographic latitude over Europe, using a method previously employed by NISBET. Summer escaping flux values range up to 9×10^{12} electrons m^{-2} sec^{-1} and winter values to 5×10^{12} electrons m^{-2} sec^{-1}. Compared at specific solar zenith angles the computed values are in good agreement with recent satellite measurements. Approximately half of this flux is lost by Coulomb collisions along the field line path. The resulting flux arriving at the local ionosphere produces ionization by inelastic collisions in the atmosphere. This additional ionization is about 3% of the ionization from local processes at summer noon and 48% at winter noon. During winter nighttime this conjugate photoelectron ionization can be significant for several hours.

Although small in magnitude, this additional ionization should systematically modify the summer total electron content depending on geographic location. The large seasonal differences in the relative impact ionization may explain in part the F-layer seasonal anomaly. This source may be important for maintaining and causing enhancements in the winter nighttime ionosphere.

22. An Experimental Study of VLF Mode Coupling and Polarization Reversal
P. Rodriguez and D. A. Gurnett
(accepted for publication, J. Geophys. Res., 1970).

Below the proton gyrofrequency, both polarization reversal and mode coupling of the right and left hand modes of propagation can occur. In this paper an experimental study of polarization reversal and mode coupling of electron and proton whistlers is presented. The occurrence of polarization reversal for a whistler signal observed in the ionosphere is indicated by the presence of a proton whistler. Mode coupling between the right and left hand modes of propagation is indicated by the occurrence of both electron and proton whistler signals at the same frequency.

Mode coupling is observed to occur most frequently over a range of about 35° - 55° magnetic latitude. Below about 35° magnetic latitude, polarization reversal is the

predominant effect, whereas above about 55° magnetic latitude neither mode coupling nor polarization reversal occur and proton whistlers are not observed. These results are compared with existing theories to explain this latitude dependence.

23. Theory of the Injun 5 VLF Poynting Flux Measurements
S. R. Mosier and D. A. Gurnett
(accepted for publication, J. Geophys. Res., 1970).

This paper presents the theory of the VLF Poynting flux measurement technique used on the Injun 5 satellite. This technique consists of using one electric antenna and one magnetic antenna, both oriented perpendicular to the geomagnetic field and to each other, to determine the direction of the VLF Poynting flux up or down the geomagnetic field. The conditions for which the Poynting flux direction determinations are valid are considered, including the effects of errors in the magnetic orientation of the spacecraft and the simultaneous presence of many waves.

24. Poynting Flux Studies of Hiss with the Injun 5 Satellite
S. R. Mosier
(submitted to J. Geophys. Res., 1970).

A study of very-low-frequency hiss emissions in the region 677 to 2528 km and 35° to 75° invariant latitude (in the northern hemisphere) using the Injun 5 Poynting flux measurement technique is presented. Downgoing ELF hiss is observed over the entire region of altitude-invariant latitude space under study, whereas ELF hiss having an upward-directed net Poynting flux is only observed at invariant latitudes below about 60°. A new propagation phenomenon is proposed in which downgoing ELF hiss may propagate across the plasmapause boundary to lower latitudes and become subsequently reflected and trapped within the plasmasphere. Measurements indicate that at least part of the VLF hiss which is observed by the Injun 5 satellite must be generated above the Injun 5 altitude range. A new type of sub-auroral-zone VLF hiss has been observed called mid-latitude hiss.

25. Color Spectrograms of VLF Poynting Flux Data
D. A. Gurnett, S. R. Mosier, and R. R. Anderson
(accepted for publication, J. Geophys. Res., 1970).

This paper discusses a new method of processing the VLF electric and magnetic field data from the Injun 5 satellite to produce color frequency-time spectrograms with the color indicating the Poynting flux direction, up or down the geomagnetic field. The Poynting flux sensing technique used on Injun 5 employs one electric antenna and one magnetic antenna

both oriented perpendicular to the geomagnetic field and to each other. With this antenna geometry the Poynting flux direction, up or down the geomagnetic field, can be determined from the cross-correlation between the electric and magnetic field signals. The technique used to process these signals employs a new type of spectrum analyzer/cross-correlator to determine the cross-correlation between the electric and magnetic field signals as a function of frequency and time. These data can be displayed as a two color frequency-time spectrogram using appropriate display techniques. A survey of complex VLF radio noise phenomena analyzed using this technique is presented.

26. Whistlers with Harmonic Bands Caused by Multiple Stroke Lightning
R. R. Shaw and D. A. Gurnett
(submitted to J. Geophys. Res., 1970).

Whistlers received with the Injun 5 satellite are frequently observed to have bands with decreased signal amplitude at equally spaced frequency intervals. The frequency spacing between the bands is typically about 10 to 30 Hz. As many as 30 such bands have been observed on a single whistler.

Because the frequency spacing of these bands is comparable to the gyrofrequency of several types of positive ions found in the ionosphere (particularly O^+ or N^+) it was initially thought that these bands may be produced by a hot plasma effect resulting from wave-particle interactions at harmonics of the ion gyrofrequency. Subsequent investigations have shown that the bands are instead due to double or multiple strokes in the initial lightning discharge which result in destructive interference of the whistler signals at equally spaced frequency intervals. The frequency spacing between the interference bands is given by the inverse of the time interval between the lightning strokes. This simple explanation for these bands accounts for a number of peculiar characteristics which could not be accounted for with the gyrofrequency harmonic interaction hypothesis.